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SHORT REPORT
Pacific islands which escaped the 1918–1919 influenza pandemic and their subsequent mortality experiences

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SUMMARY

Very few Pacific islands escaped the 1918–1919 influenza pandemic. Subsequent influenza epidemics in the established colonial outposts of American Samoa and New Caledonia infected many but killed very few persons whereas the extraordinarily isolated Niue, Rotuma, Jaliut and Yule islands experienced high mortality influenza epidemics (>3% of population) following 1918. These dichotomous outcomes indicate that previous influenza exposure and degree of epidemiological isolation were important mortality risk factors during influenza epidemics on Pacific islands.

Key words: Mortality, Pacific islands, pandemic influenza, 1918.

The influenza pandemic of 1918–1919 rapidly spread throughout the world. On a few Pacific islands, quarantine procedures effectively protected the islands' residents from pandemic-related influenza when strict administrative measures were implemented by forewarned governing authorities. Beginning in October 1918, Australia stopped shipping from its ports to surrounding islands including New Guinea and New Caledonia [1]. On Samoa, the U.S. Navy instituted a quarantine that protected American Samoa from the pandemic; in contrast, on Western Samoa, >20% of the population died after influenza was brought to the island from Auckland, New Zealand [2]. Other islands avoided pandemic influenza in 1918–1919 due to their extreme socioeconomic and maritime isolation; such islands probably included the New Hebrides, Solomon Islands, as well as the Gilbert and Ellice Islands in the Southwest Pacific Ocean [3].

Because island quarantines are not sustainable indefinitely, influenza viruses eventually affected the islands that had escaped the pandemic in 1918–1919. The extremely high overall mortality that was associated with the 1918–1919 pandemic, and the relatively high mortality in young adults (W-shaped mortality curve), are unique characteristics of that pandemic. It is not clear, however, whether these characteristics were direct effects of an inherently hyper-virulent pandemic influenza strain and/or effects of interactions between the pandemic virus, co-circulating respiratory infectious agents (e.g. other influenza strains, pneumococci), and/or unique host (e.g. immune statuses) or environmental factors that existed at the time.

We reviewed published historical reports from several island groups as well as transcriptions of archived written records from Rotuma (provided by Professor

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Table 1. *Six Pacific islands or groups of islands* (*American Samoa, New Caledonia*) *and their influenza epidemic mortality experience following being missed by the main pandemic wave of the 1918–1919 influenza pandemic*

Island	Location in Pacific	Influenza epidemics	Mortality outcomes	Ref.
American Samoa	North of Tonga near western Samoa	1926 1929/1930	Approx. 25% ill in 1926 with estimated 1:1000 mortality	[2, 4, 5]
New Caledonia	East of Queensland, Australia	1921	Widespread illness with estimated 1:1000 mortality	[6]
Rotuma	Between Fiji and Tuvalu	1927/1928 1947/1948	3·8% died in 1927/1928 and 1·9% died in 1947/1948	[7, 8]
Yule Island	Papuan south coast north of Australia	1920 1931/1932 1940–1942	Baseline annual mortality of 3% increasing up to 6·8% during epidemic years	[9]
Niue	Between Tonga and Cook Islands	1921? 1942 1944	Estimated 4% of population including all ages died during 1944 epidemic	[10]
Jaliut	Southern Marshall Islands	1931	8·6% died in 1931 epidemic	[11]

A. Howard, University of Hawaii at Manoa) to identify Pacific islands with no reported influenza epidemics during the 1918–1919 pandemic period and to document the mortality impacts of influenza epidemics that affected those islands subsequent to the 1918–1919 pandemic period (see Table 1).

American Samoa. The maritime quarantine of American Samoa completely isolated the island during the 1918 pandemic period; there were no reports of influenza-related deaths during the pandemic period. The success of the quarantine of American Samoa reflected tight control of both the naval base at Pago Pago (by the U.S. Navy) and the extensive coastal areas (by island residents). Of note with regard to the latter, residents of Western Samoa used ocean-going canoes to seek shelter from the influenza epidemic on their home islands on nearby American Samoa. On American Samoa, entry restrictions – including a several-day wait prior to disembarking – were maintained at least until 1920. Influenza eventually arrived in American Samoa in 1926; during the ensuing epidemic, at least one-fourth of the island residents were clinically affected by influenza-related illnesses but few died. Overall mortality during the 1926 epidemic was estimated as 1/1000 island residents which was about 200 times lower than the overall mortality on Western Samoa during the 1918 pandemic-related epidemic [4, 5].

New Caledonia. Prior to 1918, Australia was a major supplier of goods to New Caledonia. However, during the 1918–1919 influenza pandemic period, restrictions instituted by the Australian Director of Quarantine ended nearly all shipping to the islands for several months. During the quarantine period, influenza was not reported on New Caledonia other than in individuals who had been isolated at the port. In July 1921, an influenza epidemic affected New Caledonia [6]. During the epidemic, an estimated 80% of the local and 42% of the European-origin population became ill; however, few influenza-related deaths were reported (deaths: local inhabitants, $n=30$; Europeans, $n=4$). The island's population at the time was estimated as 33 000; thus, overall influenza-related mortality during the epidemic was about 1/1000 [about 160 times lower than the overall mortality (16%) in residents of French Polynesia during a 1918 pandemic-related epidemic] [6].

Rotuma. Rotuma was affected by a 'virgin soil' measles epidemic in 1911; during the epidemic, about 16% of the island's population died. To the colonial administrators of the island, the experience highlighted the exceptional vulnerability of very isolated populations to first-time exposures to clinically virulent infectious agents [7]. From November 1918 to February 1919, all shipping to Rotuma was stopped to prevent influenza from reaching the island; the preventive measures were apparently successful. A review of mortality records on Rotuma from 1903 to 1960 documented sharp increases of influenza-related mortality in 1927–1928 and 1947–1948. During the respective epidemic periods, 3·8% and 1·9% of the

Rotuman population died of pneumonia/influenza (according to causes of death listed in mortality registers). Of note, pneumonia/influenza was a leading cause of death on Rotuma during much of the 20th century [8].

Yule Island (*Mekeo*). Catholic mission records from Yule Island (Mekeo) on the southern coast of Papua documented mortality on the island throughout the first half of the 20th century [9]. A review of the records revealed sharp increases in baseline annual mortality during periods of widespread influenza-like illness on Yule Island; such 'influenza epidemic periods' occurred in 1920, 1931–1932, 1940–1942 and 1948. Of note, during the 1931, 1941, and 1948 epidemic periods, influenza-related mortality was relatively high in young adults, e.g. 35–43% of all deaths were in the 20–49 years age group. The relatively high influenza-related mortality in young adults during influenza epidemics on Yule Island reflected the increased mortality risk in young adults in general (W-shaped age-mortality curve) during the 1918–1919 pandemic period [9].

Niue. Prior to the Second World War, Niue was an extremely isolated island; it had no airfield and was about 3000 km from its colonial administrators in New Zealand. As a result, during this period, there were very few arrivals to the island, and all were by sea. During the Second World War, an airfield was constructed on the island; contacts between previously isolated islanders and outsiders sharply increased. Influenza epidemics occurred in 1942, 1944, 1949 and 1957 [10]. During the 1944 epidemic, there were 2351 cases and 129 deaths; case fatality was about 5·5% and overall mortality in island residents was about 4%. During influenza epidemics in 1976, 1977, 1979, 1981 and 1983, there were high illness attack rates (>30%) but very few deaths (e.g. two in 1983).

Jaluit. Jaluit is a small atoll in the southern Marshall Islands. An influenza epidemic occurred in 1910 which killed an estimated 100 island residents – about 10% of the island population. To our knowledge, the 1918–1919 influenza pandemic did not affect Jaluit. An influenza epidemic in 1931 killed 140 persons – about 8·6% of the population [11].

American Samoa and New Caledonia were established colonial outposts that escaped the 1918–1919 pandemic because of rigid restrictions on maritime traffic [1]. Within a few years after lifting these restrictions, influenza caused high morbidity but relatively low mortality during epidemics on the islands. Of particular note, the influenza-related mortality on these islands during post-pandemic epidemics was much lower than the mortality during epidemics on similar islands during the 1918–1919 pandemic period [2, 6]. In contrast, on the very isolated islands of Rotuma, Yule Island, Niue, and Jaluit, post-pandemic influenza epidemics – some as long as several decades after the 1918–1919 pandemic period –caused high morbidity and high mortality [8–11]. Of particular note, influenza-related mortality on these islands during post-pandemic epidemics was comparable to that on similar islands during 1918 pandemic-related epidemics. Together, the findings of this report suggest that extreme social isolation is a significant determinant of mortality risk during influenza epidemics.

There are limitations to this report that should be considered when interpreting the findings. During the first half of the 20th century, the documentation of morbidity and mortality on Pacific islands – particularly, on small isolated islands – was variably complete and accurate. Moreover, in the absence of laboratory tests for influenza viruses, the reliability of reports or imputations of 'influenza' as the primary causes of epidemics or epidemic-related deaths is questionable. Some islands (particularly, small isolated islands) considered 'missed' for this report may have been affected by pandemic influenza; and some epidemics and deaths attributed to 'influenza' for this report may have been caused at least in part by other agents.

Genomic studies with mathematical modelling suggest that three lineages of influenza A(H1N1) viruses were circulating prior to 1918 [12]. As such, it is likely that influenza viruses, other than the 1918 pandemic strain, were circulating in the Pacific region during the post-pandemic period. The reader is referred to our recent hypothesis publication for our justification for thinking that multiple viruses were involved [13]. The huge difference in mortality between the highly lethal epidemic on Western Samoa in 1918 and the much less deadly epidemic on American Samoa in 1926 suggests that the epidemics were caused by different influenza viruses [2].

In the early 20th century, residents of isolated Pacific islands compared to those from more socially

interconnected communities were probably exposed to fewer and less diverse respiratory infectious agents. Such differences were probably reflected in the characteristics of their immune systems and the natures and degrees of their immunological responses to novel infectious agents including but not limited to influenza virus [14]. During post-pandemic influenza epidemics on the isolated islands, both adults and children died at high rates. The finding suggests that the immune systems of human hosts may require multiple exposures to diverse respiratory infectious agents in order to effectively – but not excessively – respond to antigenically novel and potentially virulent respiratory infectious agents.

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DECLARATION OF INTEREST

None.

REFERENCES

1. **Cumpston J.** Influenza and maritime quarantine in Australia. Melbourne: Australian Quarantine Service, 1919.
2. **Tomkins SM.** The influenza epidemic of 1918–19 in Western Samoa. *Journal of Pacific History* 1992; **27**: 171–197.
3. **Brown P, Gajdusek D, Morris J.** Virus of the 1918 influenza pandemic era: new evidence about its antigenic character. *Science* 1969; **166**: 117–119.
4. **Ravenholt R, Foege W.** 1918 influenza, encephalitis lethargica, parkinsonism. *Lancet* 1982; **2**: 860–864.
5. **Larsen A.** Some medical observations in the Pacific Islands and Dutch East Indies. *California Western Medicine* 1934; **40**: 413–417.
6. **Peltier M.** The influenza epidemic that occurred in New Caledonia in 1921 [in French]. *Bulletin de l'Office International d'Hygiene Publique* 1922; **14**: 676–685.
7. **Shanks G, *et al.*** Extreme mortality after first introduction of measles virus to the Polynesian island of Rotuma, 1911. *American Journal of Epidemiology* 2011; **173**: 1211–1222.
8. **Lambert S.** Health survey of Rotumah. *Medical Journal of Australia* 1929; **1**: 45–50.
9. **Scragg R.** Historical epidemiology in Papua New Guinea. *Papua New Guinea Medical Journal* 1977; **20**: 102–109.
10. **Taylor R, *et al.*** An epidemic of influenza in the population of Niue. *Journal of Medical Virology* 1985; **16**: 127–136.
11. **Spennemann D.** Epidemics recorded for the southern Marshall Islands 1887–1943 (http://marshall.csu.edu.au/Marshalls/html/health/epidemics.html). Accessed 24 January 2012.
12. **Smith GJ, *et al.*** Dating the emergence of pandemic influenza viruses. *Proceedings of the National Academy of Sciences USA* 2009; **106**: 11709–11712.
13. **Shanks GD, Brundage JF.** Pathogenic responses among young adults during the 1918 influenza pandemic. *Emerging Infectious Diseases* 2012; **18**: 201–207.
14. **Shanks GD, Hussell T, Brundage JF.** Epidemiological isolation causing variable mortality in island populations during the 1918–1920 influenza pandemic. *Influenza and Other Respiratory Viruses* (in press).